BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Review of AAP I/C Panel Instrumentation and Communications Interface Control Documents Case 620

DATE: July 19, 1968

FROM: A. G. Weygand

ABSTRACT

This memorandum contains comments on the drafts of the Interface Control Documents prepared for the Apollo Applications Program Instrumentation and Communications Panel by the Marshall Space Flight Center. These documents were distributed to the members of the Panel for comment prior to the tenth Instrumentation and Communications Panel meeting.

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MEMORANDUM FOR FILE

1.0 Introduction

Comments on the drafts of the following documents prepared for the Apollo Apllications Program (AAP) Instrumentation and Communications (I/C) Panel are presented in this memorandum.

(a) Saturn/AAP Frequency Plan, Instrumentation and Communications Interfaces, ICD 50M13120, dated June 12, 1968.

(b) Multiple Docking Adapter to Airlock Module Instrumentation and Communications Interface, ICD 50M13122, draft, dated May 15, 1968.

(c) LM-A/ATM/MSFN Instrumentation and Communications Performance and Interface Specification, ICD 50M 13127, draft, dated May 3, 1968.

(d) MDA/AM/OWS to MSFN Instrumentation and Communications Performance and Interface Specification, ICD 50M13126, draft, dated May 3, 1968.

2.0 Saturn/AAP Frequency Plan

Some general comments which apply to more than one of the AAP mission configuration summary sheets forming the Saturn/AAP Frequency Plan are listed below.

(a) Although the AZUSA/GLOTRAC transponder and associated equipment may not be removed from the Instrument Unit of the Saturn IB launch vehicles, no ground support for prelaunch tests or during launch powered flight will be provided. If current plans call for this transponder to be inactive during subsequent Saturn IB launch vehicle missions, the AZUSA/

GLOTRAC entries should be deleted from this document. If current plans call for this transponder to be active during subsequent Saturn IB launch vehicle missions, it is recommended that a footnote be added stating that the AZUSA/GLOTRAC transponder will not be supported.

(b) After successful orbit insertion has been confirmed, a safe command will be sent to the secure range safety system of the S-IVB stage of the Saturn IB launch vehicle which permanently deactivates the destruct package. Consequently, the period of activity of the secure range safety receiver of the S-IVB stage is from lift-off until insertion into Earth orbit rather than from lift-off through the lifetime of the S-IVB/IU.

(c) To date, no requirement has been identified for telemetry transmissions via a VHF communications link from the LM to the CM/SM during the nominal unmanned rendezvous and docking of the LM/ATM with the cluster or during rendezvous and docking of the CM/SM and the LM/ATM in a contingency situation. Therefore, it is recommended that entries pertaining to LM to CM/SM data transmission capability be deleted from this document until a requirement for this capability is identified.

(d) In the current AM baseline design, the VHF FM transmitters will not be active during the launch phase. It is possible that real-time data from the MDA/AM/OWS will be required during the launch phase. If this becomes a requirement, one of the three VHF FM transmitters would be active during the launch phase for transmission of real-time telemetry. In any event, not all three VHF FM transmitters of the AM will be active during the launch phase as is indicated in this document by the period of activity designation "C". In addition, the VHF FM transmitters of the AM will not be active in Earth orbit continuously, but will be active (controlled manually or via ground command) only during those periods when the AM is within line-of-sight of an MSFN station capable of supporting the three VHF communications links from the AM.

In the radio frequency summary sheet for mission AAP-4, it should be noted that the VHF FM/FM telemetry link from the Instrument Unit, DF-2, will be deactivated after orbital insertion as is the VHF SS/FM telemetry link from the Instrument Unit, DS-1. This decision was made at the Preliminary Requirements Review (PRR) for the ATM (see RID number D-7 and its disposition).

3.0 Multiple Docking Adapter to Airlock Module Instrumentation and Communication Interface

Since the high level and low level multiplexers used in the MDA including the multiplexer associated with the Experiment Support System (ESS) are only qualified for use in a vacuum, all such multiplexers must be mounted external to the pressurized portion of the MDA. Because the multiplexer associated with the ESS cannot be mounted on the ESS and because the ESS is portable and may be used in either the MDA or the OWS, it is likely that this multiplexer will be mounted near the PCM interface box of the AM located between the MDA and OWS. Since the ESS and its mutliplexer have been separated, different interfaces have resulted between the ESS and the MDA (or OWS) and between the MDA and the PCM telemetry system of the AM. It is suggested that this interface between the MDA and the AM be specifically addressed in this ICD. Reference should be made to the proper ICD for these measurements routed from the ESS through the MDA/AM interface to the PCM telemetry system of the AM.

It is recommended that the number of high level multiplexers and the number of low level multiplexers installed in the MDA be included in this ICD.

It is not clear that the power interface between the AM and the MDA should be addressed in this ICD. If such a specification is appropriate, power is required for suit microphone and amplifiers, speaker/intercoms, and MDA instrumentation such as tranducers, signal conditions, ESS, etc., in addition to power for suit biomedical instrumentation which is specified in this ICD. If such a specification is not appropriate, the section of this ICD dealing with biomedical power should be deleted.

The interface between the MDA and the AM should provide passage for the necessary wiring for switch closure circuits required between the caution and warning systems of the AM and the LM and the CM. An additional paragraph should be added to describe this caution and warning system portion of the MDA/AM hardwire interface.

4.0 LM-A/ATM/MSFN Instrumentation and Communications Performance and Interface Specification

In general, the LM-A/ATM/MSFN Performance and Interface (P&I) Specification does not contain enough information to permit the calculation of the performance of each of the communications links between the LM-A/ATM and the MSFN. Since this document will become a spacecraft to MSFN interface control document after appropriate approvals have been obtained, it is necessary that a sufficient number of parameters be specified in this document to guarantee compatible and successful operation of the various communications links between the LM-A/ATM and the MSFN in any of the required modes during the planned LM-A/ATM mission.

For the Unified S-Band (USB) communications link between the LM-A and the MSFN, it is recommended that Tables 1 and 4 of the LM-A/ATM/MSFN P&I Specification be replaced by the tables which will be described below. The various modes of operation of the USB communications link between the MSFN and the LM-A and between the LM-A and the MSFN which could be used during the LM-A mission should be specified as is done in Tables 1 and 3, respectively, which are attached to this memorandum. It should be noted that Table 3 does not include all of the possible modes of operation of the LM-A to MSFN USB communications link, but is limited to an arbitrary set which the writer believes to be sufficient for the planned LM-A mission. The information on communications parameters called for in Tables 1 and 2 (attached to this memorandum) when obtained will enable the evaluation of the performance of all modes of the USB communications link from the MSFN to the LM-A. Similar information on the LM-A USB transmit characteristics and MSFN USB receive characteristics as is called for in Table 2 on the LM-A USB receive characteristics and MSFN transmit characteristics in conjunction with the information called for in Table 3 will enable the evaulation of the performance of selected modes of the USB communications link from the LM-A to the MSFN. These tables are similar to those contained in the LM P&I Specification for the Apollo Program. It is recommended that all applicable entries in the LM-A/ATM/MSFN P&I Specification describing the LM-A/MSFN USB communications interface be direct extractions from the LM/MSFN P&I Specification for the Apollo Program.

For the UHF command link from the MSFN to the ATM, it is recommended that the communications system parameters listed in Table 2 of the LM-A/ATM/MSFN P&I Specification be augmented to include: (a) carrier peak-frequency deviation,

(b) antenna pointing loss, (c) receiver AGC dynamic range and (d) minimum signal to noise ratio at some point in the receiving system necessary to meet the command link performance requirements stated in Section 3.1. The term "equivalent noise temperature" used in Table 2 of the LM-A/ATM/MSFN P&I Specification requires clarification. The point of reference in the receiving system for this temperature is needed as well as knowledge of whether or not the noise temperature contribution from external sources through the spacecraft antenna is included (e.g. galactic noise).

For the VHF telemetry links from the ATM to the MSFN, it is recommended that the communications system parameters listed in Table 3 of the LM-A/ATM/MSFN P&I Specification be augmented to include (a) antenna pointing loss, (b) receiver AGC dynamic range, and (c) minimum signal to noise ratio at some point in the receiving system necessary to meet the telemetry link performance requirement stated in Section 4.1. It is recommended that the entries in Table 3 pertaining to the structure and format of the PCM signal be deleted from Table 3. The PCM telemetry data formats are discussed in greater detail in Section 4.2.2.1.1 of the LM-A/ATM/MSFN P&I Specification. It should be noted that the entries in the "Vehicle Characteristics" column of Table 3 for "RF Circuit Losses" and "Antenna Gain" have been transposed.

With reference to Section 3.0 of the LM-A/ATM/MSFN P&I Specification, it should be added that updating of the ATM Flight Control Computer and the ATM Digital Computer is accomplished via the UHF command system of the ATM.

With reference to Section 4.0, it is recommended that a paragraph be added describing the PCM telemetry data format of the LM-A to the same level of detain used in the description of the PCM and ASAP telemetry data formats of the ATM already contained in this section.

5.0 MDA/AM/OWS to MSFN Instrumentation and Communications Performance and Interface Specification

The operational requirements for the MSFN to MDA/AM/OWS command system discussed in Section 4.1 of the MDA/AM/OWS/MSFN P&I Specification do not cover the command requirements (up to 224 discrete commands) of the Workshop Altitude Control System (WACS). Under current MSFC plans, two command decoders will be added to the existing command system of the AM (one for each of the redundant command receivers of the AM)

to serve the WACS exclusively. The audio output of each of the redundant AM command receivers would be routed in parallel to a different one of the existing AM command decoders and to a different one of the added command decoders added to serve the WACS.

It is stated in Section 4.2 that each command message will contain 30 prime data bits each of which is encoded into 5 subbits. This is true for all messages used for selecting an on-board stored program command. However, a command message used for executing one of the 32 real-time set/reset commands will contain only 12 prime data bits: (a) 3 bits-vehicle address, (b) 3 bits-system address, and (c) 6 bits-information.

The comments contained in Section 4.0 of this memorandum on Table 2 of the LM-A/ATM/MSFN P&I Specification also apply to Table 1 of the MDA/AM/OWS P&I Specification. Clarification is required on the specification of AM antenna gain when discussing the AM command system. Each of the redundant AM command receiver units consists of two radio frequency receivers whose outputs are combined prior to being routed to a command decoder. One receiver of each unit will be connected to one antenna element and the second receiver of each unit will be connected to a second antenna element. The AM has two VHF/UHF antenna systems, a launch antenna system and an Earth orbit antenna system. The launch antenna system consists of two whip antenna elements located approximately 90 degrees apart on the stationary portion of the SLA. The Earth orbit antenna system consists of two discone antennas mounted on different booms and switchable and one of the whip antenna elements used in the launch antenna system. The received output of one of the whip antenna elements is connected permanently to one of the receivers of each of the redundant command receiver units. The second receiver of the redundant command receiver units is switched to the other whip antenna during the prelaunch and launch phases of the mission and between the two discone antenna elements during the Earth orbital phases of the mission after the antenna booms have been deployed.

The comments contained in Section 4.0 of this memorandum on Table 3 of the LM-A/ATM/MSFN P&I Specification also apply to Table 2 of the MDA/AM/OWS/MSFN P&I Specification.

It is recommended that Section 6.0, "C-Band Tracking," of the MDA/AM/OWS/MSFN P&I Specification be deleted because the MDA/AM/OWS will be a passive target for the ground-based C-band radars and no question of compatibility between the instrumentation of the MSFN and the MDA/AM/OWS exists. If

this section is to be retained, it is suggested that characteristics of ground-based C-band radars be added as well as the minimum radar cross-section area of the MDA/AM/OWS for any arbitrary attitude to permit calculation of the performance of skin tracking the MDA/AM/OWS by the various types of ground-based C-band radars.

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Attachments
Table 1-3

Table 1

MSFN Station to Lunar Module S-Band Transmission Combinations

Combination	Modulation	Subcarrier Frequency	Carrier Peak Phase Deviation
1. Carrier PN Range Code	PM	-	
2. Carrier Voice	FM/PM	30 kHz	
3. Carrier Up-Data	FM/PM	70 kHz	
4. Carrier PN Range Code Voice	PM FM/PM	- 30 kHz	
5. Carrier PN Range Code Up-Data	PM FM/PM	- 70 kHz	
6. Carrier Voice Up-Data	FM/PM FM/PM	30 kHz 70 kHz	
7. Carrier PN Range Code Voice Up-Data	PM FM/PM FM/PM	- 30 kHz 70 kHz	

Table 2

MSFN Station to Lunar Module S-Band Communications Characteristics

Functions and Parameters	LM Receive Characteristics		MSFN Station Transmit Characteristics	
	Value	Tolerance	Value	Tolerance
1. Overall Receiving and Transmitting Characteristics				
a. Frequency				
b. Second IF Predetection Bandwidth				
c. Interference Rejection				
d. Power Output				
e. Receiver Noise Figure				
f. Antenna Bandwidth				
g. Antenna Gain				
h. Antenna Pointing Loss				
i. Antenna Polarization				
j. Beam Ellipticity				
k. Circuit Loss				
l. Transmitted Incidental Phase Modulation				
m. Transmitted Incidental Amplitude Modulation				

Table 2 (continued)

MSFN Station to Lunar Module S-Band Communications Characteristics

Functions and Parameters	LM Receive Characteristics		MSFN Station Transmit Characteristics	
	Value	Tolerance	Value	Tolerance
n. Receiver AGC Dynamic Range				
2. Carrier Tracking				
a. Threshold Loop Noise Bandwidth ($2B_{LO}$)				
b. Strong Signal Loop Gain				
c. Dynamic Tracking Threshold				
d. Tracking Rate				
e. Maximum Frequency Excursion				
f. Maximum Phase Error				
g. Minimum S/N (RMS/RMS) Required in $2B_{LO}$				
3. Ranging Channel				
a. Type				
b. Modulation				
c. Bit Rate				
d. Clock Frequency				
e. Video Bandwidth				
f. Time Delay Variation				
g. Absolute Time Delay as Measured at Input/ Output of LM Antenna				
4. Voice Channel				
a. Subcarrier Frequency				
b. Modulation				
c. Peak Frequency Deviation				
d. Frequency Response				

Table 2 (continued)

MSFN Station to Lunar Module S-Band Communications Characteristics

Functions and Parameters	LM Receive Characteristics		MSFN Station Transmit Characteristics	
	Value	Tolerance	Value	Tolerance
e. Amplitude Control				
f. Predetection Bandwidth				
g. Minimum Required Predetection S/N (RMS/RMS) for Proper Detector Operation				
h. Post Detection Bandwidth				
i. Required Post Detection S/N (RMS/RMS) for ___% Intelligibility				
5. Up-Data Channel				
a. Subcarrier Frequency				
b. Modulation				
c. Peak Frequency Deviation				
d. Frequency Response				
e. Predetection Bandwidth				
f. Minimum Required Predetection S/N (RMS/RMS) for Proper Detector Operation				
g. Post Detection Bandwidth				
h. Required Post Detection S/N (RMS/RMS)				

Table 3

Lunar Module to MSFN Station S-Band Transmission Combinations

Combination	Modulation	Subcarrier Frequency	Carrier Peak Phase Deviation
1. Carrier			
PN Range Code	PM	-	
Telemetry (51.2 kbps)	FM/PM	1.024 MHz	
Voice/Biomed	FM/PM	1.25 MHz	
2. Carrier			
Telemetry (51.2 kbps)	FM/PM	1.024 MHz	
Voice/Biomed	FM/PM	1.25 MHz	
3. Carrier			
Telemetry (51.2 kbps)	FM/PM	1.024 MHz	
4. Carrier			
PN Range Code	PM	-	
Telemetry (51.2 kbps)	FM/PM	1.024 MHz	

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Subject: Review of AAP I/C Panel Instrumentation and Communications Interface Control Documents

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